Another matter with regard to which a greater definiteness seems desirable, even at the expense of some generality, is the theory of the action of the voltaic cell.

Nernst's theory of the electrolytic "solution-tension" of a solid—solution-pressure is a preferable term—is stated in his own words, but they are vague:

"We must ascribe," it is said, after a reference to osmotic pressure, "to a dissolving substance in contact with a solvent, similarly, a power of expansion, for here also the molecules are driven into a space in which they exist under a certain pressure. It is evident that every substance will pass into solution until the osmotic partial pressure of the molecules in the solution is equal to the 'solution-tension' of the substance" (pp. 231-232).

We may put the whole theory slightly differently, thus:—

In the case when a substance is being dissolved in such a way that *molecules* pass from the solid into the liquid, the pressure rises in consequence of the impacts of these molecules on the walls of the containing vessel; now when molecules also pass from the liquid into the solid, the "evident" fact is that the steady state is reached when the numbers entering and leaving the liquid are the same. In such a case the osmotic pressure measures the solution-pressure, and no electrical action is involved.

But now let us suppose that a metal is passing, not in the form of *molecules*, but in that of *ions* into water. Each of these ions carries with it a positive charge; the water therefore tends to become positive, the metal negative, and an electrical double layer is formed over the surface of separation. The charged ions are not free to move throughout the water, but few escape from the surface; hence the additional pressure due to the impacts of the metallic ions—the solution-pressure, as it is called—is small.

Again, let us take the case of a metal, such as copper, in a solution of one of its own salts, say copper sulphate; here, also, if there were no electrical effects, we might suppose that copper *molecules* would be deposited out of the sulphate on to the metal, while other molecules would leave the metal; the steady state would be reached when these two sets of molecules became equal in number, and the osmotic pressure would become—in reality, unless the solution were very weak, would *fall* to—the solution pressure. But according to the theory, the copper passes as *ions* which carry with them out of the solution their positive charge; this they give up to the metal on becoming molecules. And since we suppose that, unless the solution be very weak, the number of copper ions leaving it is, to start with, greater than those entering, the metal becomes positive, the negative ions of the solution are attracted to it, the positive ions driven off, a double layer is again formed; a difference of electrical potential is established between the metal and the solution—the metal being positive, the solution negative.

If, however, we consider a metal, such as zinc, which has a high solution pressure when immersed in, say, zinc sulphate, we must suppose that at the start more metallic ions leave the metal than enter it, the solution thus becomes positive, the metal negative, and the double layer formed is one which tends to prevent the positive metallic ions from leaving the zinc, and is thus opposite to that formed on the copper.

In both these cases we must suppose, when the steady state is reached, that the ions leaving the metal leave it under the solution pressure of the metal in the liquid. This may be seen as follows: If there were no electrical force called into action, the pressure would go on changing in the liquid up to the solution pressure, when the number of metallic ions leaving the surface would balance those entering.

Thus the solution pressure measures the whole amount of momentum which the ions of the metal tend to transfer per second across unit area of the surface. Now according to the theory this momentum depends on the metal only, and the tendency to transfer momentum remains the same, however the transfer be stopped; in reality, the electrical forces acting across the double layer stop it, not the opposing momentum of the liquid ions, and the pressure exerted by these electrical forces must be therefore equal to the solution pressure of the solid, *i.e.* when a current is flowing the positive ions start from the metal at the solution pressure of the metal, and become, when in the solution, ions at the osmotic pressure of the liquid.

Now, however, let us suppose that a piece of copper is connected to the zinc, the two being dipped into zinc sulphate; and suppose further, for simplicity, that there is no action at the interfaces zinc-copper or copper-liquid, then negative electricity from the zinc passes over to the copper through the zinc-copper junction, attracting to itself the positive ions in the solution and destroying the double layer at the zinc-liquid junction; thus a current of positive electricity passes through the solution from zinc to copper. The source of the E.M.F. is at the zinc-liquid junction, arising from the fact that more zinc ions pass from the zinc into the solution than from the solution into the zinc; or, as Nernst would put it, that the solution pressure of the zinc is greater than the osmotic pressure of the liquid. In reality, of course, there may be actions at both the other junctions similar in character to that which we have supposed to go on at the junction of the zinc and the liquid, and the resultant E.M.F. depends on all of these.[1]

In this simple case the energy of the cell is obtained from the passing of the zinc ions from the saturation pressure of the zinc to the osmotic pressure of the liquid, and we obtain at once Nernst's expression for the electromotive force, varying as $RT \log_e P/p$, where P is the saturation pressure, p the osmotic pressure.

But an article which started as a notice of Mr. Jones' most useful book is in danger of becoming a dissertation on the seat of the electromotive force of a voltaic cell, a result to be avoided.

R. T. G.

MESOZOA AND ENANTIOZOA.

Traité de Zoologie Concrète. T. ii. 1re partie. *Mésozoaires—Spongiaires.* By Yves Delage and Edgard Hérouard. Pp. ix + 244. (Paris: C. Reinwald, 1899.)

As might have been anticipated, this part of the massive "Traité de Zoologie," which is now in course of publication, contains matter of exceptional interest. One-fifth of the present issue is devoted to the Mesozoa,

[1] A reference should be made to Prof. Lodge's article in the May number of the *Philosophical Magazine*, which has appeared since the above wa written.

and the remainder to the Sponges. The Mesozoa are classified provisionally under four divisions:—(1) Mesocœlia for *Salinella*; (2) Mesenchymia for *Trichoplax* and *Treptoplax*; (3) Mesogonia for *Dicyemidae* (parasitic in the renal sacs of dibranchiate Cephalopods) and *Orthonectidae* (parasites of Nemertines, Ophiurids and Polychaets); (4) Mesogastria for *Pemmatodiscus*.

Salinella has been regarded as the incarnation of an ideal promorph, the true *Mesozoon*, or link between unicellular and multicellular animals. The minute creature which has been saddled with so grave a responsibility was found, in 1892, by the late Dr. Frenzel in a jar of 2 per cent. salt solution containing mud taken from the salt works of Cordoba, in the Argentine Republic. The jar had been exposed for a long time, and some iodine washings had been thrown into it by mistake. The authors of the "Traité" give a full account of *Salinella*, and admit that, if it really exists, "c'est le vrai Mésozoaire."

When the complex character of the structure and life-history of the higher Protozoa is considered, the imputed simplicity of *Salinella* becomes almost grotesque, and it seems impossible to assign a cosmic importance to it, even should its autonomy become, in future years, an established fact.

> "On ne le dit pas, mais il règne une certaine méfiance vis-à-vis de cet être venu si à propos, recueilli dans des conditions si étranges, observé si loin de nous et une seule fois. Ce vase contenant un liquide artificiel, exposé à l'air et aux poussières, qui a reçu les rincures de la verrerie d'une table d'histologiste, ce pays lointain, tout cela ne prouve rien d'une manière positive contre la Salinelle."

Trichoplax and *Treptoplax* are likewise aquarium-products, the former having been found at Trieste, in 1883, by Prof. F. E. Schulze, and the latter at Naples, in 1892, by Prof. F. S. Monticelli. These forms, which superficially resemble an acœlous Turbellarian, are riddles of the aquarium, like *Salinella* in this respect, and it seems premature to draw far-reaching conclusions from them until they are themselves solved.

The authors of the "Traité" introduce new matter into their account of the Mesogonia derived from a work written in Russian by N. A. Keppen, in which the spermatozoa of *Dicyema* are described and figured for the first time. Attention is drawn to the mystery surrounding the dissemination of the Dicyemid parasites from one host to another, since it is only the infusoriform males which can endure immersion in sea-water, this being quickly fatal to the vermiform females.

Pemmatodiscus is a gastruliform organism found by Monticelli (1895), living in closed sacs in the jelly of a Medusa, *Rhizostoma pulmo*. It would no doubt have excited enthusiasm twenty years ago. Its right to be regarded as an independent type is founded upon three considerations, namely, its parasitic habit, its inability to endure immersion in sea-water, and its power of multiplying by division. The first and last of these reasons are by no means conclusive, since parasitic larvæ, as well as embryos contained in brood-pouches, are known among Medusæ, as is also the phenomenon of embryonic fission.

An account of Haeckel's Gastræadæ is given on pp. 38 and 39, by way of appendix. One might almost have expected to find that the apocryphal Physemaria would have been allowed to go the way of *Bathybius* and *Eozoon*.

A second appendix (pp. 40–45) is devoted to the ciliated urns found in the body-cavity of Sipunculids. These are regarded by M. M. Kunstler and Gruvel, whose original drawings are here published for the first time, as being certainly parasites, and not forming part of the organisation of the Sipunculid. Two genera are described, *Kunstleria* n.g. from *Phymosoma*; and *Pompholyxia*, Fabre-Domergue, from *Sipunculus*.

In their treatment of the Sponges, the authors tread on firmer ground, and the result of their labours is a most satisfactory performance. As promorph (type morphologique) of the entire group, they select for preliminary description the *Olynthus* of Haeckel. *Olynthus* is a generalised abstraction which has its embodiment in concrete zoology. Admitting that a treatise on Sponges at present could hardly be introduced in any other way, it may be pointed out that there are reasons for doubting whether the phyletic value of the *Olynthus* is as great as its undoubted morphological and didactic importance.

In the section devoted to the calcareous sponges (pp. 66–82), the authors quote freely from the researches of our compatriots, Prof. E. A. Minchin and Mr. G. P. Bidder. The classification recently suggested by Bidder is given *in extenso* on p. 67, although not adopted in the body of the work.

The sextets of actinoblasts which secrete the triradiate spicules of Ascons, as discovered and described by Minchin, are duly recorded, but the figure reproduced on p. 67 gives no idea of the excellence of the illustrations contained in Minchin's monograph.

The complete inversion of the layers, which takes place at the metamorphosis (pp. 60, 69, 106, 159), marks one of the most interesting phases of sponge-life. The primitive endoderm of the larva gives rise to the permanent epidermis of the adult, while the primitive flagellated ectoderm sinks in to form the flagellated chambers of the adult. This fact of inversion has induced Delage to separate the Sponges, under the designation Enantiozoa, from all other Metazoa.

The metamorphosis of the parenchymula-larva is accompanied by phenomena which have an interest extending beyond the limits of sponge-lore. The account given on pp. 110–111 shows the following succession of events which occurs in some cases during the conversion of the flagellated ectoderm of the larva into the choanocytes (collar-cells) of the adult:—

I.	II.	III.	IV.
Flagellated Ectoderm.	Histolysed Ectoderm.	Syncytial Ectoderm.	Choanocytes.

The reconstructions on the coloured plates, which elucidate the increasing complexity of the inhalent and exhalent canal systems throughout the group, are well executed, and produce a satisfying impression of solidity and reality. If there is a complaint to be made, it is that, in not a few cases, the authors have omitted to add in brackets the name of the generic type to which the diagrams and text-figures may be taken to refer.

Textual errors and inconsistencies are rare, and obvious when they occur. A few examples will suffice. On pp. 2 and 36, the terms "cœlomique" and "cœlome" refer to a blastocœlic space; on p. 60, "gemmules" is given as an alternative expression to "bourgeons," which arise as outgrowths involving all the layers of the body (*e.g. Lophocalyx*), whereas on p. 177 the endogenous "gemmules" of *Spongilla* are rightly described as special formations, quite distinct from ordinary lateral or exogenous buds, although the buds of *Tethya* (p. 167) seem to be intermediate between the exogenous and endogenous varieties. On p. 91 (footnote), Sollas's term *collenchyme* is branded, with other related terms, as "bien inutile," but on p. 152 the superficial cortex of *Geodia* is characterised as "collenchymateuse."

In a footnote on page 203, we are reminded that H. J. Carter instituted a comparison between the flagellated chambers of sponges and the branchial sac of Ascidians. The authors add that this comparison "nous semble bien singulière aujourd'hui ou ces êtres sont mieux connus." On the contrary, the comparison is appropriate, the analogy between the flagellated chambers of a sponge (in respect of their respiratory and nutritive functions and of their relations to the inhalent and exhalent canals) and the branchial sacs of the Ascidiozooids in a compound Tunicary (*cf.* especially the Didemnidæ) being an extraordinarily close one; but of course Carter was innocent of the distinction between homology and homoplasy. What is very singular indeed is the fact that, in these latter days, the same fatal confusion between actual physiological conditions and abstract genetic relationships is constantly being repeated. A. W.

THE DURATION OF THE BRITISH COAL-FIELDS.

Les Charbons Britanniques et leur épuisement. By E. Lozé. Pp. ix + 559, and vii + 562 to 1229. (Paris: C. Béranger, 1900.)

IN France, as in the rest of Europe, consumers have during the past winter been complaining of the difficulty of obtaining an adequate supply of coal, the chief cause of the increased demand having been the activity in the iron and steel trades. At the same time, prolonged strikes in Austria and elsewhere, and the temporary cessation of the production of the collieries of Natal and Cape Colony, have lessened the supplies usually available. The prevailing scarcity of coal is a matter of serious moment to France, where, owing to the increasing depth of the collieries and the costly nature of mining operations, the quantity of coal that has to be imported from other countries grows larger every year. At the present time about two-thirds of the coal consumed in France is raised in the country; and last year the imports amounted to 10,500,000 tons, of which quantity 6,000,000 tons were obtained from Great Britain. France being so largely dependent on Great Britain, it will readily be seen that the duration of the British coal-fields is a subject of no little importance to French economists. M. Lozé has, therefore, been induced to devote two bulky volumes, covering together 1229 pages, to a critical consideration of the investigations of Prof. Stanley Jevons, the Right Hon. Leonard H. Courtney, Mr. R. Price-Williams, Mr. T. Forster Brown, Prof. E. Hull and other English writers.

The results of his studies are grouped in four sections. The first contains an account of the geography of the British Isles, with historic, geological and economic details. The second section contains a detailed description of each of the British coal-fields, with a chapter on the coal resources of the Colonies. The third section deals with commercial geography, water and railway transport, and the principal industrial centres. The fourth and last section contains an estimate of the coal supplies of the United Kingdom, with a summary of the views expressed as to their probable duration. The work concludes with a lengthy appendix dealing with cognate matters, the production and consumption of mineral fuel in various parts of the world, the constitution of the British Colonial empire, the navy and the army.

In discussing the views of the various authorities, the author prefers to accept the pessimistic forecast of Mr. T. Forster Brown rather than the optimistic estimate of Prof. Hull. Mr. Forster Brown calculates that the amount of coal of good quality remaining in the United Kingdom at a depth not exceeding 2000 feet, the depth that he regards as the limit of economical mining, is 15,000 million tons. Such is the supply on which Great Britain must base its hopes in the inevitable economic conflict with the United States. In spite of the care and accuracy with which the divergent views on the subject are set forth, it may be doubted whether the author has made out a clear case for rejecting Prof. Hull's estimates, which show that the amount of coal remaining within a depth of 4000 feet is 81,683 million tons. The criticism of Prof. Hull's views is not convincing, inasmuch as M. Lozé, who does not appear to possess a practical knowledge of geology and mining, has not followed the recent investigations as to the limits at which mining may be carried on with profit. At the present time the greatest depth at which in Great Britain mining operations may be carried on has been reached at the Pendleton colliery, near Manchester, where the deepest workings are nearly 3500 feet below the surface. This enormous depth has, moreover, been exceeded in other countries, notably in the Lake Superior district, where a shaft of the Calumet and Hecla copper mine has now attained the record depth of 4900 feet, and in Belgium, where a colliery at Mons is 3937 feet deep. Depths such as these show that the limit of depth of 4000 feet assumed by Prof. Hull is well within the bounds of possibility. In view of the marvellous efficiency of modern winding-engines, no considerations of a mechanical nature need limit the prospective depth of shafts. By far the most important obstacle to very deep mining is the increase of temperature in proportion to the depth. Here, again, the author is apparently not familiar with recent observations. Since 1848 and 1854, the dates of observations cited by him, methods of determining earth temperatures have been greatly improved, and the results recently obtained at the Paruschowitz borehole in Silesia, put down by the Prussian Government to a depth of 6573 feet, show an increase of temperature of 1° F. for every 62·1 feet. This rate of increase would not present an insuperable obstacle to mining at a depth of 4000 feet.